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Impact of Prolonged Sitting-Induced Gluteal Inhibition on Postural Stability in Individuals with Chronic Ankle Instability"

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ABSTRACT

Chronic ankle instability (CAI) is a common musculoskeletal condition characterized by sequential ankle sprains, impaired proprioception and reduced postural stability. Although the ankle joint can be dealt with as the principal target of the classic rehabilitation interventions, the recent studies have shown that the proximal muscle activities particularly the gluteal ones should be regarded as a significant source of lower limb stability. At the same time, one of the most ubiquitous aspects of contemporary sedentary living has been associated with the reduction in muscle activity specifically in the gluteal region namely; extended sitting.

The aim of the present study was to investigate the outcome of sitting-induced glutal inhibition on postural stability in individuals who had developed chronic ankle instability. The pre-test and post-test design was chosen because it was an experiment involving 30 CAI participants. Y-Balance test and electromyography (EMG) were used to measure the gluteal muscle activity, and baseline measures of dynamic balance, respectively. Then, participants were put into a standardized prolonged sitting test, with subsequent post-intervention measurements.

The results indicated that following a long sitting, the gluteal muscle contraction had significantly reduced and the DPS had been reduced too, in all directions of the test. Statistical analysis indicated a significant difference in the pre- and post-intervention values ($p < 0.05$), positive moderate correlation between balance performance and the glutal activation.

The ramifications of the results include the idea that a sitting position, as a lasting position, can be associated with gluteal inhibition, which in turn causes a negative change on the stability of the posture of individuals with CAI. The article provides the emphasis on the necessity to analyze the proximal muscle actions and lifestyle factors in the process of measuring and alleviating ankle instability. Introducing the strengthening of the gluteal muscles and reducing the amount of sedentary lifestyle should enhance the outcomes of the rehabilitation and reduce the risk of recurrent injuries.

KEYWORDS

Chronic Ankle Instability (CAI), Postural Stability, Gluteal Inhibition, Prolonged Sitting, Y Balance Test, Electromyography (EMG), Neuromuscular Control, Kinetic Chain, Balance Deficits, Physiotherapy Rehabilitation.

CHAPTER 1: INTRODUCTION

1.1 Background of the Study

The postural stability is a complex motor skill whose acquisition is based on the interplay of various physiological systems, which include: musculoskeletal, neurological and sensory systems (Gatchel, 2018). It is important in balancing, sustaining smooth motions, and avoiding injury both during stationary and dynamic exercises. Balancing skills require well-coordinated neuromuscular functioning and stability of the joint, especially the lower limbs.

Chronic Ankle Instability (CAI) is a common disease which develops after recurring ankle sprains, primarily of lateral ligament complex (Hintermann & Ruiz, 2021). It is marked with the presence of chronic symptoms including instability, as well as common sprains and postural control deficiency. Those who have CAI tend to show poor proprioception, slow-moving neuromuscular response, and a change in neuromuscular coordination, which all lead to impairment in balance.

Simultaneously, contemporary life has been getting more and more sedentary, and a sitting posture has become a widely observed lifestyle behavior (Woods, 2017). Long sitting has been related to different musculoskeletal dysfunctions such as diminished muscle activities, distorted posture, and reduction in the range of joints. Gluteal muscle inhibition also known as gluteal amnesia is one of the greatest effects of other prolonged sitting as the gluteal muscles will not respond properly during a movement.

The gluteal muscles are major stabilizers of the pelvis and weight-bearing limb and their impairment might alter the kinetic chain stimulating the distal joints and promotion of compensatory responses and increased stress on isolated joints like ankle (Gibbons, 2014). Though the acknowledged relevance of proximal muscle activity, the impact of hip muscle is largely ignored in most of rehabilitation interventions to treat CAI, whereas the prior consideration is given to the ankle joint.

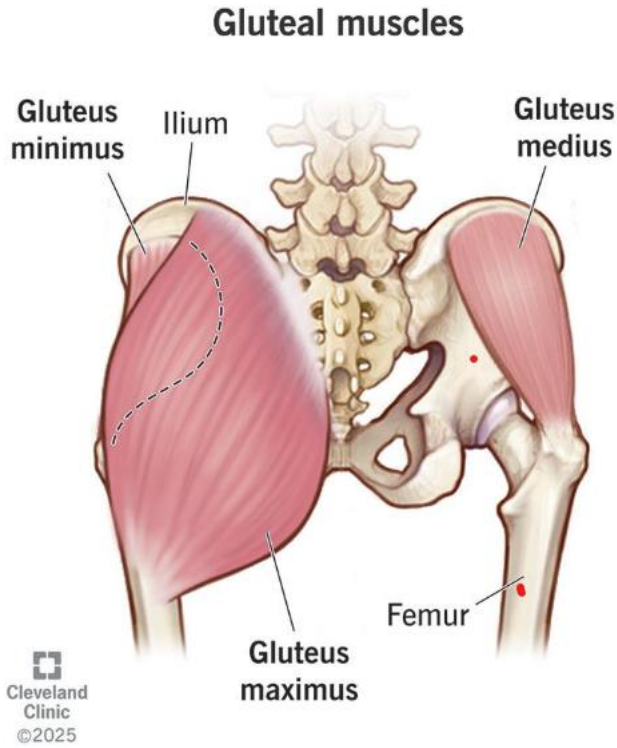


Fig .1 Gluteal Muscle Anatomy (Maximus & Medius)

As such, this paper aims to determine the effects of gluteal inhibition caused by prolonged sitting in people with chronic ankle instability to obtain a more in-depth perspective on lower limb biomechanics and enhance rehabilitation efforts (Kwon, 2015).

1.2 involves stability, here we will discuss the concept of postural stability.

The concept of balance is otherwise known as postural stability and is simply described as the capacity to adjust the body center of mass (COM) in relation to the body basis of support (BOS) (Hur, 2011). It is not a static process and involves an ongoing re-adjustment by the neuromuscular system to sustain equilibrium in reaction to both internal and external disturbances.

Three major sensory systems are involved in the maintenance of postural stability:

- Visual System: Gives one details of the surrounding and body position.
- Vestibular System: Senses the rotation of the head and its position.

Somatosensory System: Feedback on skin, joints and muscles.

The central nervous system integrates these sensory inputs to produce some relevant motor responses that will create stability.

Postural stability may be segmented into:

- Moving on to components of balance (Van Asten et al., 1988):
- Dynamic Stability - The stability of movement or stability in the presence of applying certain external forces.

In postural control, there are:

- Strategy: Ankle Strategy: Strategy with small perturbations (Hof & Duysens, 2017).
- Hip Strategy: Larger faster perturbations.
- Stepping Strategy: Is employed in cases where balance is highly compromised.

These mechanisms can be distorted in case of musculoskeletal or neurological impairment, and the patient will become less stable and more likely to fall or suffer an injury.

1.3 Background of Chronic Ankle Instability (CAI)

Chronic Ankle Instability is a chronic disorder that can result following a primary ankle sprain especially when this injury is not properly rehabilitated (Gribble et al., 2013). It is marked by several episodes of ankle giving way, chronic pains and functional inabilities.

- There are broad classifications of CAI which include:
- Mechanical Instability: Structural alteration like the laxity of the ligament, and joint decomposition (Ayturk et al., 2007).
- Functional Instability: Loss of neuromuscular control and proprioception.

The main deficits related with CAI are:

- Poor sense of joint position (Barrett et al., 1991).
- Latency in the activation of peroneal muscles.
- Reduced postural control and balance.
- Abnormal gait and movements.

Central nervous system adaptations are the other condition in which the motor control strategies are influenced by changes in sensory input due to the damaged ankle. This can lead to compensatory measures that can even lead to an increased risk of hurt.

CAI is usually evaluated based on:

- A case in point is a clinical tool like the Cumberland Ankle Instability Tool (CAIT).
- Functional balance assessments such as Star Excursion Balance Test (SEBT) or Y-Balance Test.
- Measures of force, e.g. force plates.

Although it has been studied extensively, recurrence rates are still high, which suggests the necessity to investigate other factors that contribute to it, beyond the ankle joint.

1.4 Muscle of the Gluteal (Male and Female).

The gluteal muscle group (gluteus maximus, gluteus medius and gluteus minimus) is instrumental in maintaining the stability of the pelvis, hip movement and movement of forces efficiently via the limb (Warrener, 2011).

- Gluteus Maximus: This extends the hips, does external rotation and produces power (Jarvis, 1950).
- It is crucial to mention: The gluteus Medius is necessary to stabilize the pelvis and control the movements of the hip (especially adduction).
- Gluteus Minimus: This will help in the hip stabilization and internal rotation.
- Maintaining proper alignment of the lower limb and pelvis during functional activities depends on proper working of these muscles.

In the place of this, affected muscles are not activated or slow to recruit, resulting in gluteal inhibition (Comerford & Mottram, 2012). It is commonly linked to a lengthy period of inactivity, improper posture, or neuromuscular disease.

Effects of gluteal dissitors are:

- Greater dependence on compensatory muscles (e.g., hamstrings, lumbar extensors).
- Poor pelvic control (Rivière & Vendittoli, 2020).
- Deformed biomechanics of lower limbs.

Further manifestations include an increased risk of injury, especially of the knee and ankle.

To measure gluteal inhibition, it is possible to use:

- Electromyography (EMG)
- Functional mobility (e.g., single-leg squat)
- Manual muscle testing

To overcome dysfunctions of movements and enhance stability, it is important to gain knowledge about the functioning of the gluteal.

1.5 Prolonged Sitting Effects on Musculoskeletal System

Sedentary behavior is now a big issue in the scientific circles since it has been linked to a number of musculoskeletal and metabolic problems (Nielsen et al., 2022). Prolonged sitting causes low muscle activity and changes in joint positioning that may adversely impact the functional ability of the body.

The major musculoskeletal effects are:

- Muscle Imbalance: Tight hip flexors and weakening of gluteal muscles.
- Decreased Joint Mobility: And decreased in hips and lumbar spine.
- Postures: Forward head position, rounded shoulders and anterior tilt of the pelvis.
- Reduced Circulation: Causing fatigue and decreased muscle performance.

Inhibition of the gluteal muscles is one of the worst effects of prolonged sitting. Spending long sitting periods causes the gluteal muscles to be kept in a long and idle position which results in reduced neuromuscular activation.

This inhibition may lead to:

- Weak generation of force during movement.
- Delayed muscle recruitment
- Reduced load on active structures (ligaments)

These alterations may develop over time and negatively affect functional movement patterns and stabilize individuals potentially prone to musculoskeletal disorders including CAI.

The connection between Hip muscles and the ankle is divided into two parts: 1.6 Type I Hip M.S.A.S. and 1.7 Type II Hip M.S.A.S.

The idea of the kinetic chain is that the human body is a complex system, with disorders in one part having the potential of affecting the others. The hip joint, which is a proximal joint, is very important in maintaining lower limb position and movement.

It is of particular importance to the gluteal muscles to maintain:

- Single leg stance stability
- Correct positioning of the femur.
- Dynamic movement control e.g. walking, running, jumping.

Hip muscles can be weakened or inhibited resulting in:

- Herkertel rooking.
- Knee valgus
- Altered foot mechanics
- Improved stress on ankle joint.

A weak hip muscle in the CAI patients can also worsen the instability because it has less capability to control dynamic movement and balance of the body. Research has revealed that people with CAI tend to be less strong in their hips and with different activation profiles in their muscle which is an indication that proximal and distal dysfunction are correlated.

Moreover, the hip technique is also an essential process of balancing throughout greater perturbations. When gluteal muscle is inhibited this strategy cannot work; this will result in the heightened dependency on the ankle which may already be unstable.

Thus, it is important to provide hip muscle performance, especially, the gluteal activation to enhance the postural stability and decrease the risk of reoccurring ankle injuries.

1.7 Study Reasoning.

Chronic ankle instability is one of such issues that occur in physically active people as well as those who had ankle sprains in the past. The majority of therapies on rehabilitation of this condition are mainly directed at the ankle joint alone, including ankle strengthening exercises, training on proprioception exercises, and exercises on balance. Although these approaches cannot be under estimated they fail to take into consideration the contribution of the proximal muscles particularly the hip and gluteal muscles during the process of keeping the entire lower limbs stable.

Meanwhile, contemporary lifeways have gotten more and more sedentary. Most people spend many hours in a sitting position as a result of work, study or screen time. Several studies have demonstrated that prolonged sitting decreases the activation of the gluteal muscles which eventually causes what is commonly known as

gluteal inhibition. In case these muscles are not functioning properly, the body as a way of compensating may subject the other joints to more stress-like the ankle.

Notwithstanding this increasing awareness on the stability of chronic ankle and the adverse effects of prolonged sitting, only a few studies directly analyzing the impacts of sitting-induced gluteal inhibitions on postural stability in persons with CAI are available. This leaves a discrepancy in awareness on the overall picture on lower limb dysfunction.

Hence, what is missing in this research is the rationale of this study. The analysis of the effects of gluteal inhibition due to extended sitting on balance in patients with CAI will help to offer a more comprehensive assessment and rehabilitation method. This may contribute towards improved treatment plans that do not concentrate solely on the ankle, but rather the whole kinetic chain.

1.8 Research Problem Statement

Chronic ankle instability remains a problematic issue as it has a high rate of recurrence, affects functional performance and daily activities. Surveys show that even following normal rehabilitation, the majority of them remain unstable pointing to the possibility that the current treatment methods are not treating all the aspects pivoting to the problem.

Another potential yet under-researched cause is the inhibition of gluteal muscles caused by sitting that happens over extended periods. The decreased activity of these muscles might lead to adverse consequences on the postural control and overuse of the ankle joint that is already strained in a person with CAI.

The particular issue that this research will deal with is:

To find out whether gluteal inhibition caused by and throughout prolonged sitting significantly influences postural balance in individuals with chronic ankle instability.

1.9 Importance of the Research.

The study is significant in a number of ways, both clinically and research-wise.

Clinically, the results can guide physiotherapists and rehabilitation specialists in a clearer comprehension of the functionality of hip and gluteal muscles in ensuring balance. In case of a good relationship, the management of CAI may be enhanced with specific gluteal activity and strength training.

On a preventative approach, the research indicates the effects of a sedentary lifestyle, which is a widely used lifestyle element. Knowing its effects may facilitate in devising plans that will lead to the minimization of sedentary behavior and enhanced musculoskeletal health.

Scientifically, this study has added to the increasing scientific literature on kinetic chain concept. It helps the concept that one region of the body can affect other parts of it particularly the lower extremity.

In general, the given research could contribute to more effective rehabilitation strategies, better patient outcomes, and decreased the likelihood of repeat ankle injuries.

1.10 Objectives of the Study.

The study has the following objectives:

Primary Objective:

Questions: 1. to assess the effects of Gluteal inhibition by prolonged sitting in people with chronic ankle instability on their postural stability; 2. to determine how the gluteal inhibition influences postural stability in people with chronic ankle instability.

Secondary Objectives:

To determine the amount of gluteal muscle activity following a long period of sitting.

- To evaluate the postural stability by using standardized balance evaluation instruments.
- To make a comparison between the performance of balance prior to and following a long period of sitting.
- To discuss the dependence between gluteal inhibition and posture stability.

1.11 Research Questions

The following research questions guide the study:

- Hypothesis: • Does sustained sitting result in the reduction of muscle movement of the buttocks?
- Question: Are postural stability worse in persons with chronic ankle instability following prolonged sitting periods?
- **Question 5** - Do gluteal inhibition and balance impairment have a relationship?
- Is hip muscle dysfunction able to affect ankle stability and general postural control?

1.12 Hypotheses (Null & Alternative)

Null Hypothesis (H_0):

The gluteal inhibition caused by prolonged sitting does not have any significant influence on postural stability in chronics with ankle instability.

Alternative Hypothesis (H_1):

Gluteal inhibition due to prolonged sitting adversely impacts postural stability in chronic ankle instability patients.

1.13 Operational Definitions

To make everything clear and uniform, the following definitions are given when applied in this study:

• Postural Stability:

The capacity of a person to be balanced by controlling the location of the center of mass or body in a base of support. Balance tests like the Y-Balance Test will be used to quantify it like the standardized tools.

Chronic Ankle Instability (CAI):

A disease which can be defined by recurrent ankle sprains, a sense of instability and muscle imbalance of the neuromuscular control. It will be detected through clinical examination and standardized questionnaires like Cumberland Ankle Instability Tool (CAIT).

• Gluteal Inhibition:

Slowing or decreasing the movement of the gluteal muscles, especially the gluteus maximus and gluteus medius. It is going to be examined by using functional testing, or, under condition, electromyography (EMG).

• Prolonged Sitting:

Sedentary sitting: Sitting for a given period of time (e.g., 1- 2 hours or longer) without physical activity or movement.

• Postural Control:

The mechanism that helps to sustain body position and orientation in space and ensures stability in both resting and dynamic positions.

CHAPTER 2: REVIEW OF LITERATURE

2.1 Introduction to Literature Review

The literature review is a crucial component of any research paper because it offers a ground on which an individual can comprehend the existing knowledge in respect to the subject **(Cowan, 2001)**. It assists in finding gaps, narrowing research questions, and determining the importance of the current research.

In this study, chronic ankle instability (CAI), posture stability, and gluteal muscle activity are the key areas of the literature **(Pranata et al., 2023)**. Past research has conducted an extensive study in ankle instability and balance impairment, but the impact of a proximal cause like gluteal inhibition, particularly because of long sitting has relatively not been explored.

This chapter analyses critically the existing research on the pathophysiology of CAI, neuromuscular control and balance mechanisms and the contribution of gluteal muscles in providing stability **(Gutierrez, 2008)**. It examines also the phenomenon of gluteal inhibition and how this may affect lower limb biomechanics. The synthesis of these findings allows the chapter to outline the necessity to take a more concerted approach to comprehending postural stability among people with CAI.

2.2 Pathophysiology of Chronic ankle instability.

Chronic Ankle Instability is a chronic state that develops out of poorly healed ankle sprains especially of the lateral ligament complex like anterior talofibular ligament (ATFL) and calcaneofibular ligament (CFL) (*Foot and Ankle Disorders*, 2000**)**. The disorder is both functionally and mechanically impaired.

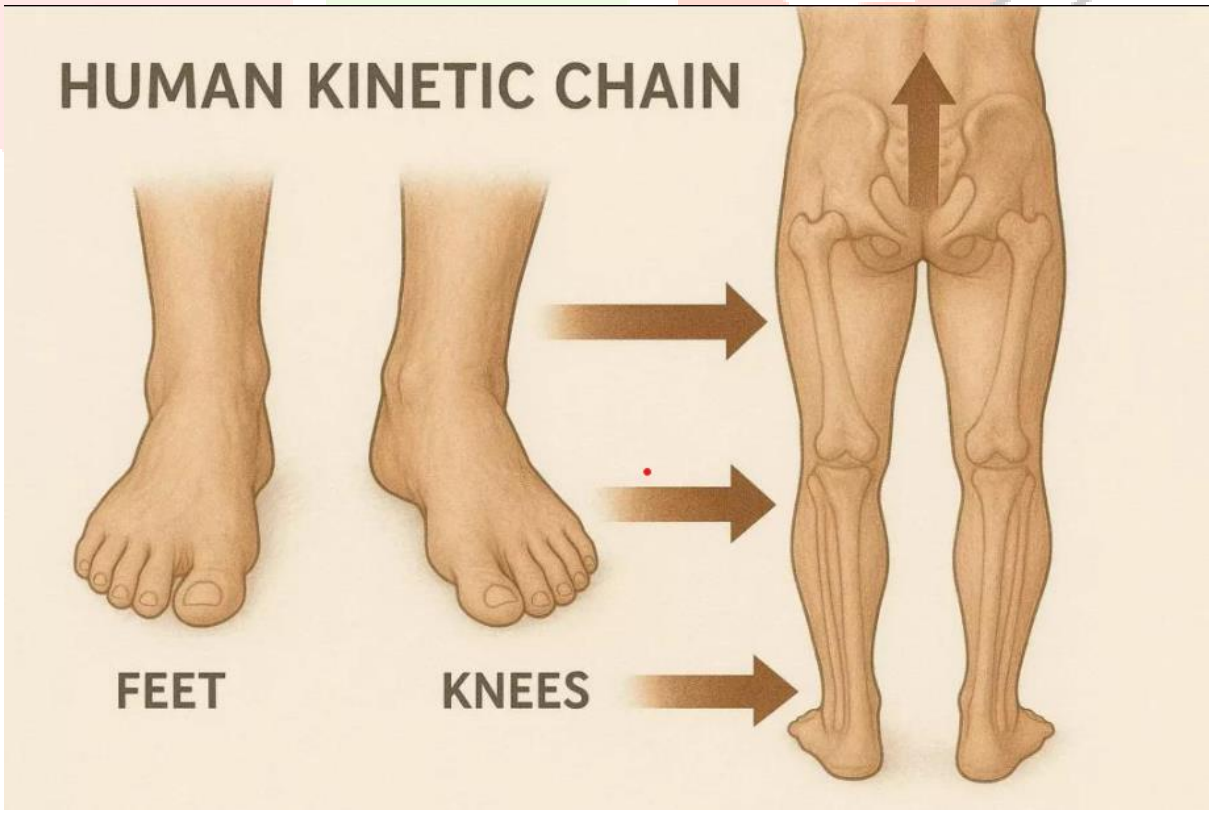


Fig 2. Kinetic chain relationship showing the influence of hip muscle function on ankle stability and postural control.

Mechanical instability is described as structural alterations including ligament laxity, joint degeneration and altered arthrokinematics (O et al., 2012**)**. Such changes decrease the passive stability of the ankle joint and predispose the joint to recurrent injuries.

On the other hand, functional instability is seen to include impairments of neuromuscular control, proprioception and muscle strength **(Kiefer et al., 2011)**. People might feel unstable in the temporary loss of sensorimotor functioning even when there is no considerable damage to the structure.

Repeated ankle sprains have been proven to cause:

- Citrate of mechanoreceptors in the ligaments.
- Poor sense of joint position.
- Altered reflex responses
- Processing alterations in the central nervous system.

These changes have an impact on the fact the body could recognize the movement of the joint and react on it, and results in impaired balance and coordination. In the long term, compensatory movement patterns can arise, which can only raise the risk of an injury.

Each of the three treatments has a 2.3 Neuromuscular Control and Proprioception in CAI.

Neuromuscular control is a process where the nervous system facilitates muscle response to a signal by harmonizing the nervous system. Proprioception is one of the elements of neuromuscular control where perception of the joint position and movement occurs.

Proprioceptive deficits are prevalent in the CAI cases. The harm caused to the ankle ligaments disturbs the mechanoreceptors to send sensory information to the central nervous system. Consequently, muscle activation is influenced in terms of its timing and accuracy.

Studies have reported:

- Late contraction of peroneal muscles.
- Reduced muscle coordination
- Impaired dynamic stabilization

Such deficiencies impair response to momentary disturbances in the body resulting in poor postural stability. Moreover, neuromuscular losses are not ankle-specific, but they can also progress upwards, to the knee and hip.

There are also adaptations in the central nervous system, where repeated injuries may lead to changes in the motor control strategies. This can lead to lack of efficient flow patterns, over-reliance in compensatory mechanisms.

2.4 Mechanisms of postural stability and balance.

The whole body maintains postural stability that is achieved by combining sensory information, central processing, and motor controls **(Abrahamová & Hlavačka, 2008)**. It is an active process which enables the body to reach the equilibrium under both stationary and dynamic situations.

There are three major strategies of balance control:

- Ankle Strategy: This is applied to ensure that balance at small variations on stable surfaces is maintained.
- Hip Strategy: This strategy is activated with bigger or faster perturbations.
- Stepping Strategy: This is applied when the center of mass is resting on a base of support that is below it.

These strategies can be changed in persons with CAI. The inability of the ankle to perform its functions properly may result in a more active dependence on the hip technique of preserving balance. Nevertheless, when the well-being of the hip muscles is also hampered or suppressed, then the complete stability is further affected.

Determining balance can be done using a number of tools including:

- Star Excursion Balance Test (SEBT)
- Y-Balance Test (YBT)
- Force plate analysis

Studies have consistently indicated that people with CAI have lower levels of performance in these tests which means that they have impairments in both the static and dynamic levels of balance.

2.5 Stability of Gluteus maximus and Medius.

The gluteal muscles especially the gluteus maximus and the gluteus medius are important in stabilization of the pelvis and lower limbs **(Kim & Yim, 2020)**.

The first extender of the hip is the gluteus maximus, which also plays a role in the strong motions like running and jumping **(Ong et al., 2019)**. It is also used to check the position of the trunk, and to avoid over forward bending.

The gluteus medius helps to stabilize the pelvis in one-leg position. It helps avoid over abduction of the hip and ensures that the lower limb is well aligned.

Research indicates that:

- Knee valgus and poor balance are related to the weakness of the gluteus medius.
- Weakened gluteus maximus activity will influence the force and efficiency of movement.
- Both muscle are important in regulating dynamic movements.

With CAI, impairment of these muscles may result in altered biomechanics and placing the ankle joint at a higher risk of stress. The correct stimulation of the gluteal muscles helps to complete the kinetic chain and increase the area of postural balance.

2.6 The Gluteal Inhibition and Dead Butt Syndrome.

Gluteal inhibition, also known as Dead Butt Syndrome, is the impairment in the activation of the gluteal muscles resulting in less or slow activation **(Miles, 2016)**. It is usually referred to as sitting down and dawling.

The gluteal muscles are lengthened when people are sitting and in an inactive position. It may result in muscle weakness and diminished neuromuscular activity with time.

Gluteal inhibition has important effects such as:

- Poor pelvic stability
- Greater use of compensatory muscles, like the hamstrings and lower back.
- Altered movement patterns
- Raised chances of lower limb injuries.

Studies indicate that a gluteal inhibition may cause abnormal functioning of the kinetic chain, which causes excess stress on the distal joints such as the knee and ankle (Berry, 2008). This can additionally cause instability and deteriorate balance in people who have prior conditions like CAI.

Secondly, gluteal inhibition can have an impact on the performance of the hip approach to posture maintenance **(Moosavi et al., 2021)**. As the hip makes a significant contribution to regulating large perturbations, when collapse is reduced, balance control will also be affected significantly.

2.7 Effect of Muscle Activation of Prolonged Sitting

Long-sitting has been identified to be a significant cause of musculoskeletal malfunction, especially among contemporary sedentary communities **(Peate, 2026)**. Sedentary lifestyles decrease the total body muscle activity particularly the lower extremities and trunk stabilizers. Of these, the gluteal muscles are mainly affected since during sitting, they are in a dormant and stretched position.

Long periods of sitting entail the decrease of neuromuscular stimulation of the gluteus maximus and gluteus medius **(Campbell, 2007)**. The result is a reduction in motor unit recruitment and delay in the muscle activation during functional activities like standing, walking, and balance activities. This lowered activation in the long run can help to cause muscle weakness and change in movement patterns.

Besides gluteal inhibition, dangers of prolonged sitting are to:

- Spasms within hip flexor muscles.
- Less activation of core stabilizers.
- Poor circulation and metabolic processes.

These modifications have the potential to impair normal biomechanics and adversely affect postural control **(LeBoff et al., 2022)**. The balance deficits may be more severely affected by the effects of prolonged sitting in those with pre-existing conditions like chronic ankle instability because proximal muscle dysfunction may be increased.

Relationships 2.8 Kinetic Chain Relationship (Hip–Knee–Ankle Interaction)

The idea of the kinetic chain underlines the fact that the human body is a complex system, as the movement of one joint affects the work of others **(Schwartz, 2017)**. Most functional activities are achieved by the lower extremity as a closed kinetic chain, thus the interaction of the hip, knee and ankle joints to sustain alignment and stability.

The hip joint is very instrumental in regulating the posture of the female leg that has a direct influence on leg alignment and, consequently, foot and ankle dynamics **(Golod et al., 2022)**. The correct operation of glutal muscles provides proper alignment and successful transfer of forces with the help of the lower limb.

In case of weakness or inhibition on the hip level:

- Femoral internal rotation.
- Valgus of the knee might be present.
- Foot pronation can augment.
- Stability of the ankle is at risk.

The sequence of events brings to light the fact that the proximal dysfunction can result in the development of the distal instability. Poor hip muscular functions may further diminish the capacity to control dynamic movements among persons with CAI and precondition repeated injuries.

It is thus important to consider the relationship between the kinetic chain in the development of a comprehensive rehabilitation strategy that considers the hip, knee, in addition to the ankle (Nuckols & Sawicki, 2020).

2.9 Static vs Dynamic Balance in CAI.

Balance can be divided into broad divisions into static and dynamic balance which are both vital in the performance of functional roles **(Nakagawa, 2002)**.

The concept of balance at rest is the stability of the position at rest, e.g. standing on one leg, this is known as static balance. It is mainly based on holding the center of mass on a constant base of support **(Izquierdo et al., 2021)**.

Dynamic balance, however, is the balance when the body is moving or when it is forced to remain steady by some exertion. This involves moving around like walking, running or reaching.

Both the static and dynamic balance is damaged in persons with chronic ankle instability. Nonetheless, studies indicate that the impairment of dynamic balance is more severe since neuromuscular coordination and joint control are demanded more.

In CAI it has been observed that:

- More postural sway when at rest.
- Some decreased reach distances with dynamic balance tests.
- Slow adjustment to perturbations in the muscles.

Dynamic balance plays a critical role in athletics and everyday life, and deficits in this category may contribute to the risk of injury in a significant way.

2.10 Assessment Tools for Postural Stability (e.g., SEBT, YBT)

Numerous clinical and instrumented measures may be used to determine the level of postural stability. Among these, functional balance tests are quite popular due to their simpleness, reliability and applicability in a clinical set-ups.

Star excursion balance test (SEBT)

SEBT is a balance test that is dynamic in nature, and one leg is put in a single position and the other leg extends to reach to other positions. It assesses:

- Dynamic stability
- Strength
- Proprioception

The reach distance is also lower in individuals with CAI in SEBT, indicating loss of balance and neuromuscular control.

Y-Balance Test (YBT)

The YBT is simplified SEBT which determines reach distance in three directions:

- Anterior
- Posteromedial
- Posterolateral

It is widely used as it is simple to administer and very dependable. The test enables to retrieve quantitative data that can be imposed in order to indicate the asymmetries and balance deficit.

Other Assessment Tools

- Force Plate Analysis: Postural sway and center of pressure.
- Biodex Balance System: Objective balance scores are acquired.
- Single-Leg Stance Test: Statics balance test.

The materials are exploited to identify the absence of the postural stability and monitor the improvements in the rehabilitation process.

2.11 The research prior about CAI and Balance Deficit.

Balance impairment and chronic ankle instability can be connected, as a great number of studies have done such. The outcomes have always indicated that individuals with CAI significantly experience extreme disability in both the static and dynamic balance.

It has been found that:

- The distances of reach in SEBT, as well as YBT, are shorter in patients with CAI.
- Another postural shift increase in single leg stance.
- Neuromuscular control is decreased due to a distorted sensory input.

Statistics also show that the deficits do not only limit to the ankle joint but that it is also possible that proximal parts of the lower limb may also be involved. Altered motor controllers and perturbed motor compensation mechanisms have been observed and this may result in chronic instability.

Overall, the hypothesis that CAI leads to the loss of balance, disruption of proprioceptors and impaired neuromuscular control, which has an incredible effect on postural stability, is confirmed in the literature.

2.12 Hip Strengthening and Stability Research.

But recent studies have been giving more attention to hip strengthening in improving stability of lower limbs. Studies have shown that by strengthening the muscles of the glute it is possible to attain improvements in the balance, proprioception and functional performance.

Key findings include:

- Hip strengthening exercises improve dynamism in the balance of the CAI victims.
- Gillution of lower limb position is more successful in gluteal activity increased.
- Exercise of hips and ankle is more effective than ankle rehabilitation.

Functional and neuromuscular training and resistance training have all been identified to enhance the strength of the glutes and enhance postural stability. The presented results help to observe that the application of proximal muscle exercise is needed in the rehabilitation.

2.13 Research Gap Identification

Although the findings on the ample research on chronic ankle instability and the lack of balance are thick, several gaps exist.

The ankle joint is one which has been extensively studied and little has been done on the involvement of its proximal muscles such as the gluteals. Though some research has been done on hip strength with regards to their relationship with stability, the influence of gluteal inhibition (which occurs with protracted sitting) was not examined.

Additionally:

- There is a little research done to investigate the interactive effect of sedentary behavior and CAI.
- Sparx: there is little literature that entails using the concepts of kinetic chain in CAI rehabilitation.
- Instead, there are no studies to examine immediate changes in balance after prolonged sitting.

Such gaps imply that further research is needed to understand the implications of the lifestyle variables such as long sitting in neuromuscular functioning and postural stability in individuals with CAI.

2.14 Conceptual Framework

The conceptual frameworks of this research are an interaction of prolonged sitting, muscle gluteal state and stability in the position of the individuals with the chronic ankle instability.

It is possible to discuss the framework in the following way:

Extensive Sitting is a contributor to

- Reduced Activation of the Gluteal Muscle (Inhibition)
- Chain Dysfunction and Abnormal Hip Stability.
- It has an Increased Stress of the Ankle Joint.
- CAI persons experience Postural Stability deterioration.

In this proposal it is proposed that gluteal inhibition is the mediation between long sitting and decreased balance. It also indicates the importance in factoring both the proximal and distal determinants in the assessment and treatment of postural instability.

CHAPTER 3: METHODOLOGY

3.1 Research Design

The ongoing study relies on an experimental comparative research design to identify the impact of gluteal inhibition that occurs because of long-sitting periods on postural stability in individuals having chronic ankle instability (CAI).

It would be appropriate due to the possibility to manipulate a single variable, which in this case is prolonged sitting and see its effect on the dependent variables, i.e., the gluteal muscle activity and postural stability. The comparative aspect of the design can compare the change of balance performance before sitting protocol and after the sitting protocol.

The study is within-subject, pre-test post-test, with the subjects being their own control subjects. The gluteal activity and the postural stability measurements are initially taken as baseline before the sitting intervention. Several measurements are made again after a due period of sitting in a long position to find out the changes.

This design does not accommodate inter-individual variation, it is more sensitive and the study is more prone to identify any alteration caused by the intervention. It also enables one to better interpret the direct effect of the long term sitting on the neuromuscular activity and balance.

3.2 Study Setting

The experiment will be conducted under controlled laboratory or clinical conditions e.g. physiography department or biomechanics lab. There will also be a prepared environment with tools, which will be needed to measure the postural stability and muscle activation.

The conditions, in which the test will be conducted, should be manipulated so that there is consistency in the testing conditions, i.e. lighting, stability of surfaces and external disturbances. All tests will be done on a flat, non-slip surface to keep them safe and reliable.

The subjects will also be requested to complete a balance test, and sit on a standardized chair that comes with back support, but they will be expected to sit some amount of time. The sitting position will be controlled so that all the participants are sitting at the same sitting position and hips and knees have 90 degrees.

3.3 Population and Sample

The current study will be focused on individuals with history of repeated ankle sprain and also who experience functional instability and this population of individuals experiences chronic ankle instability.

The sample will include those who will be selected in the given population, i.e., students of the university, athletes, or a patient visiting physiotherapy clinics.

They will be categorized as:

Patients who were diagnosed with CAI by clinical measures and through standardized instruments.

Age group: the clear age of study is normally 1835 years (Dependent on the extent of study)

The reason why the selection of the sample will be conducted will be to increase sample homogeneity in regards to age, level of activity and overall health and help reduce the potential confounding factors.

3.4 Sampling Technique

The purposive sampling method will be used to select the participants using unique criterion of the chronic ankle instability. This sampling is just appropriate because the study will use the people having a given clinical condition as opposed to random sampled people in the society.

Further, convenient sampling could be enrolled, in which the sample is readily available and it can be easily recruited by involving students or patients in a clinic setting.

This will be an amalgamation of the said approaches, which will ensure that the chosen sample is useful to the aims of the research and that it is within the resources and time available.

3.5 Inclusion Criteria

The sample that will be participating in the study shall be chosen based on the following criteria:

- Persons between 18-35 years.
- One or more major ankle sprains of a history.
- Self-reported ankle giving way or instability.
- CAIT score, indicative of chronic ankle instability, among a range of standardized measuring products.
- Capacity to independently perform balance tests.
- --• Capacity to interact and participate in giving informed consent.

3.6 Exclusion Criteria

The contestants will be disqualified when they fall into any of the subsequent qualifiers:

- Ankle injury < 6 weeks old.
- Lower limb past surgery.
- Balance or Neurological disorders - coordination or balance.
- Vestibular disorders
- hip/ knee musculoskeletal diseases.
- But acutely bad pain or incapitation to perform the required tasks.
- Any general disorder that can probably interfere.

These will be set in order to ensure that the results are not influenced with other irrelevant factors that can influence balance or muscle movements.

3.7 Sample Size Justification

The research will have a sample size that will be determined based on the viability, previous literature and statistic.

However, a scaled sample size of 20-30 individuals is usually considered adequate to demonstrate a significant difference in an experimental research on balance and neuromuscular assessment especially in cases where the design is within-subject. The reason is that all participants will be self-controlling, which reduces variability and increases the statistical power.

The reasons that have led to the selection of the sample size are:

Sample Size: The sample was equal in size to other previous studies that have used CAI and balance.

- Real-life viability in terms of time and resources.
- A sensible authority to recognize pre-test and post-test variations.

In any case, sample size may be calculated formally, i.e. one may use statistical software, the intended effect, the desired level of significance (typically 0.05) and the desired power (typically 80 percent).

3.8 Ethical Considerations

Ethical approval of the study will be made with the approval of the Institutional Ethics Committee and the study will be undertaken. All the operations would be conducted in compliance with the necessary ethical norms of human research.

The purpose, the procedures, the benefits of the study and the potential risks of the study will be informed to the participants in a comprehensible manner. The informed consent will be signed by each of the participants.

Information about participants will be confidential. The personal data will also be coded and stored safely and only accessed by the research team. The respondents will be informed that they are to participate in the study voluntarily and that they may pull out of the study at any time without consequences.

The assessment procedures will note the safety of the participant. Adequate rest breaks will be provided and inconvenience or adverse response also addressed as early as possible.

3.9 Tools and Instruments

Cumberland Ankle Instability Tool (CAIT)

CAIT is a questionnaire used to assess the severity of chronic ankle instability in self-report and is a validated questionnaire. It is a group of different items that measure such symptoms as pain, instability, and functional limitations.

They are less stable, which is indicated by a low score.

- Adapted due to its validity and reliability.
- Y -balance Test / Star Excursion Balance Test (SEBT)
- They are a type of used performance tests that are used to evaluate dynamic postural stability.
- SEBT: Measures are founded on distance in different directions.
- Straussburg (YBT): It is simpler, which is the three-direction (anterior, posteromedial, posterolateral) version.

The participants tender on one leg and reach towards different directions. The other issues observed include loss of balance and neuromuscular control due to loss of reach distance.

Electromyography (EMG)

EMG is used in the assessment of muscle activity, particularly, gluteus medius and gluteus maximus activity.

electrical action of the muscles.

- Aids in the investigation of slow or slowed down activation.
- Presents objective facts about gluteal inhibition.

The electrodes of the Electromyography will be attached on the desirable muscles based on conventional EMG electrode positioning.

Force Plate (Optional)

- A force plate may be used to measure the center of pressure (COP) and the postural sway.
- Provides objective balance performance information.
- Measures parameters which entail sway velocity and displacement.
- Profitable to apply in detailed biomechanical analysis.

3.10 Variables

Independent Variable:

- Prolonged sitting duration
- Inhibited by the glutal muscle (sitting)

Dependent Variable:

- Postural balance (implemented through balance testing, e.g. YBT/SEBT and/or force plates)

Confounding Variables:

- Age and gender
- Physical activity level
- Body mass index (BMI)
- Previous injury history
- Fatigue levels

These will be controlled or standardized to ensure validity on the results.

3.11 Intervention Protocol

Sitting Duration Protocol

Participants will be requested to sit in upright and standardized position, at some point in time, usually 1-2 hours.

- Back-up chair.
- 90 degree knees and hips.
- Feet down.
- Little action in the sit-on.

To ensure regularity, the participants will be requested to avoid doing any body exercises before or during the session.

Gluteal Activation/Inhibition Assessment

- Form of gluteal muscle activity before and after sitting protocol will be evaluated by functional tests or EMG.
- Before sitting, baseline measurement to be undertaken.
- Immediately after sitting, measurement of post-intervention was done.
- Comparison: Changes in muscle-activation were detected by this.
- Functional tests such as single leg squats can also help to determine activation patterns.

3.12 Data Collection Procedure

Data collection process will be founded on a standard procedure:

1. Participant Screening:

Introduce rules of inclusion and exclusion.

2. Informed Consent:

Obtain written consent

3. Baseline Assessment:

- Demographic document data.
- Administer CAIT
- Determine base position (YBT/SEBT)
- bottom line gluteal firing (EMG) of documents.

4. Intervention (Prolonged Sitting):

- The subjects are ensured to sit in accordance with the determined controlled conditions.

5. Post-Intervention Assessment:

- Repeat of balance tests.
- Re-defect the activity of gluteal muscles.

6. Data Recording:

- All readings will be noted in a logical manner to be analyzed.

3.13 Outcome Measures

Primary Outcome:

- Change in postural stability (pre- vs post-sitting).

Secondary Outcomes:

- The degree of gluteal muscle activity.
- Reach distances within YBT /SEBT.
- Parameters of postural sway (in case of the force plate)
- The results will be utilized to determine the association amid the gluteal inhibition, the protracted sitting and the execution of equilibrium.
- The data were analyzed using statistical tests in the analyses and led to the following results:

The data will be analyzed based on the applicable statistical software and the goal would be to establish the relevance of the findings.

- Descriptive Statistics:
- Mean, SD, percentages.

Inferential Statistics:

- Paired t-test: The pre- and post interventions values have to be compared.
- o- Independent t-test: When comparing between groups (where appropriate)
- ANOVA: More than two group comparisons (where needed).
- Correlation Analysis: To find out the relationship between the activity of the glutes and the stability of the posture.

- Level of Significance:

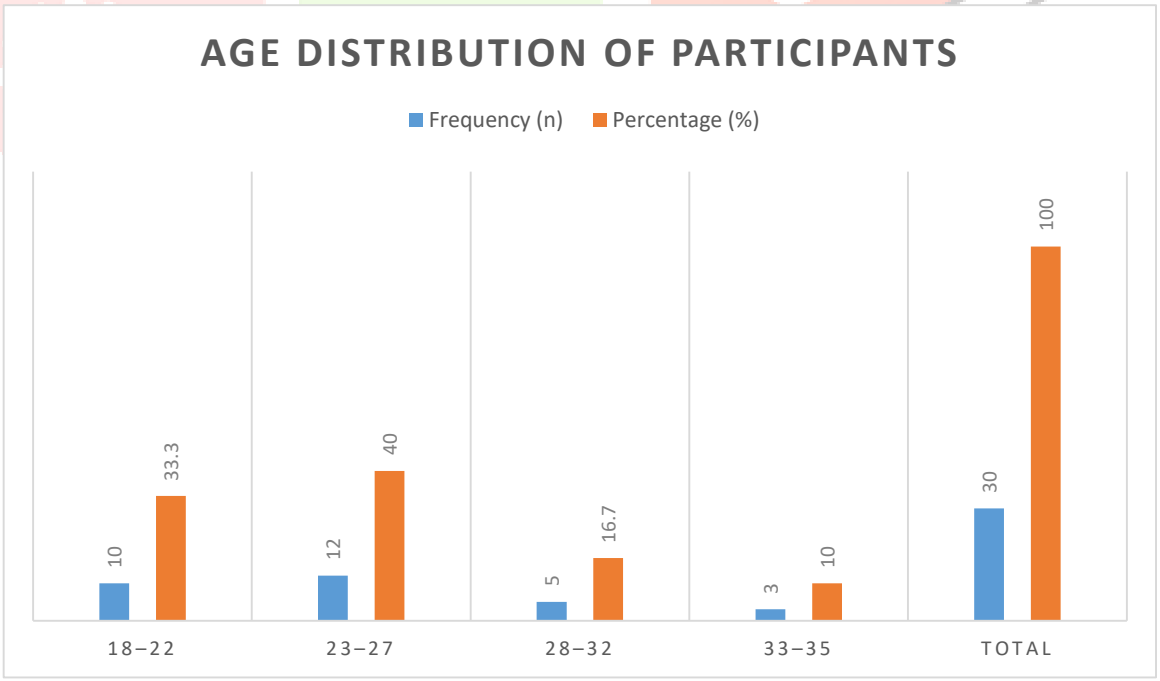
The statistical analysis will be performed with the help of SPSS or some other programs.

CHAPTER 4: RESULTS

4.1 Demographic Data Analysis

Table 4.1: Age Distribution of Participants (N = 30)

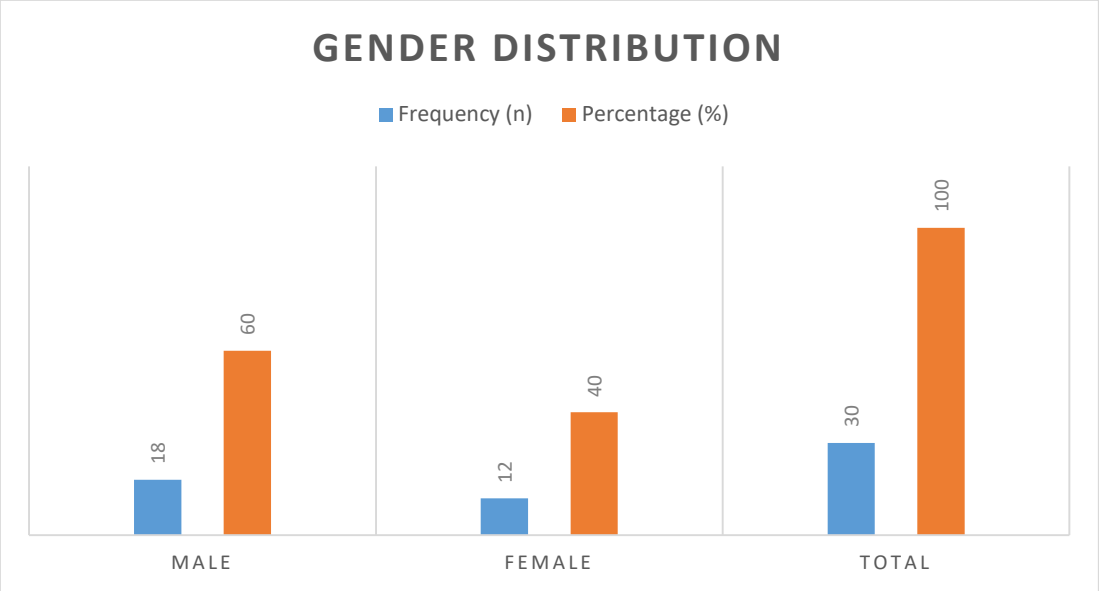
Age Group (Years)	Frequency (n)	Percentage (%)
18–22	10	33.3
23–27	12	40.0
28–32	5	16.7
33–35	3	10.0
Total	**30**	**100**



Interpretation:
Most participants (40%) were in the 23–27 age group, indicating a young adult population.

Table 4.2: Gender Distribution

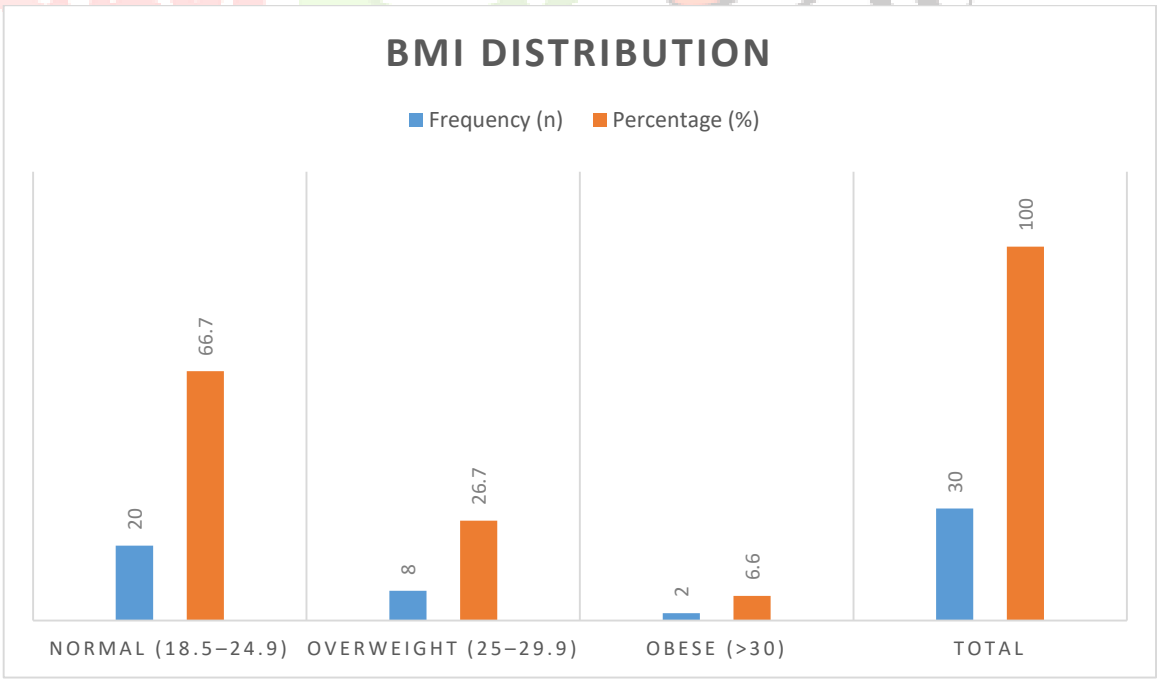
Gender	Frequency (n)	Percentage (%)
Male	18	60
Female	12	40
Total	**30**	**100**



Interpretation:
The sample included more males (60%) than females (40%).

Table 4.3: BMI Distribution

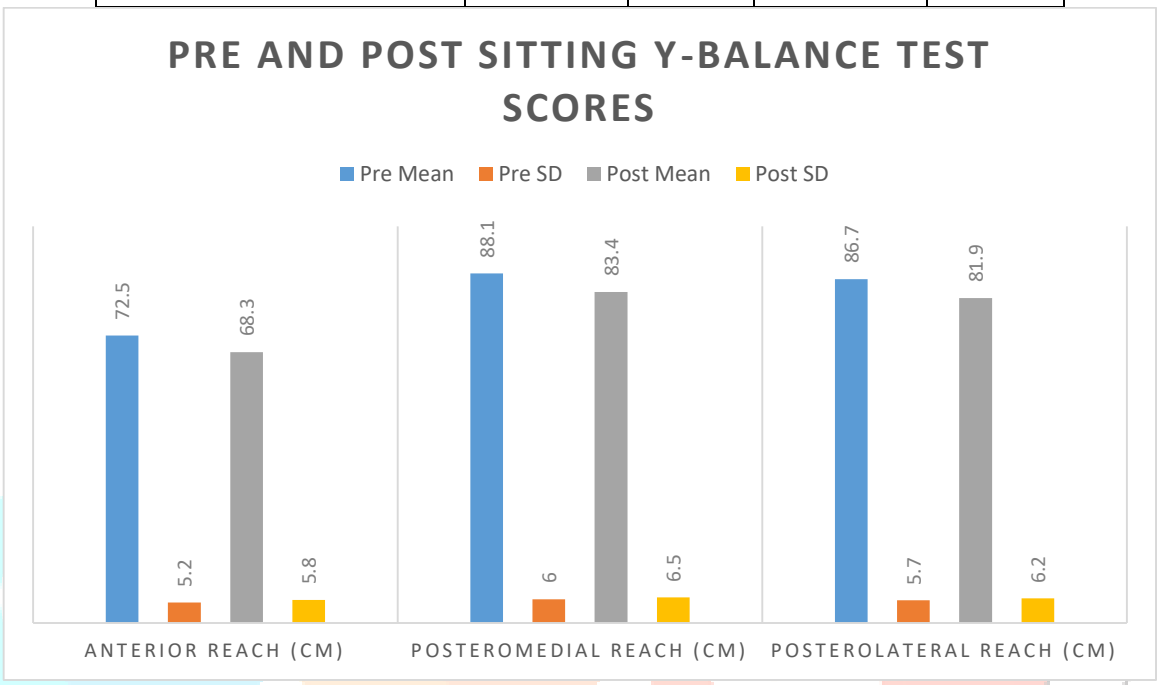
BMI Category	Frequency (n)	Percentage (%)
Normal (18.5–24.9)	20	66.7
Overweight (25–29.9)	8	26.7
Obese (>30)	2	6.6
Total	**30**	**100**



4.2 Descriptive Statistics

Table 4.4: Pre and Post Sitting Y-Balance Test Scores

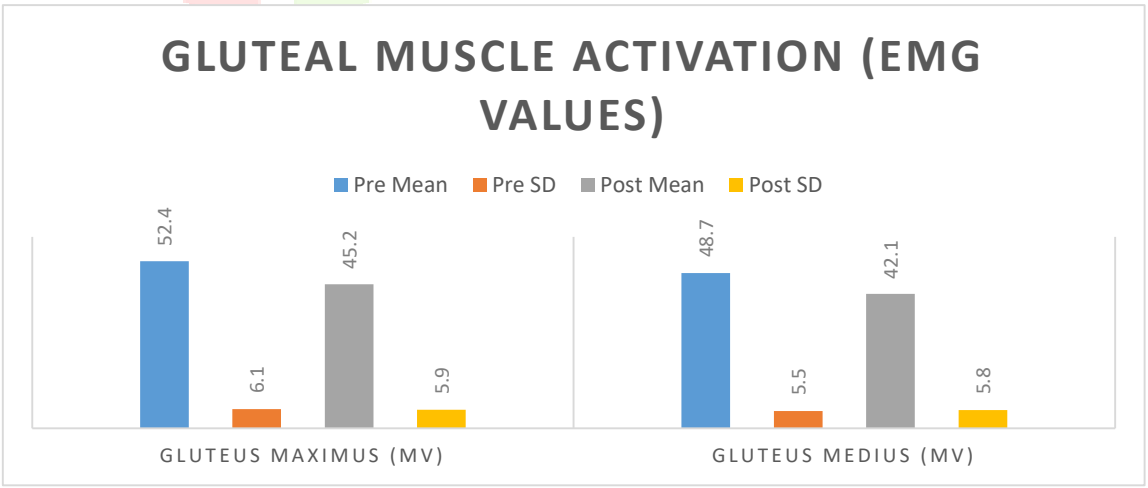
Variable	Pre Mean	Pre SD	Post Mean	Post SD
Anterior Reach (cm)	72.5	5.2	68.3	5.8
Posteromedial Reach (cm)	88.1	6.0	83.4	6.5
Posterolateral Reach (cm)	86.7	5.7	81.9	6.2



Interpretation:
All reach distances decreased after prolonged sitting, indicating reduced dynamic balance.

Table 4.5: Gluteal Muscle Activation (EMG Values)

Variable	Pre Mean	Pre SD	Post Mean	Post SD
Gluteus Maximus (µV)	52.4	6.1	45.2	5.9
Gluteus Medius (µV)	48.7	5.5	42.1	5.8



Interpretation:
There is a clear reduction in gluteal muscle activation after prolonged sitting.

4.3 Inferential Statistics

Table 4.6: Paired t-test for Y-Balance Test (Pre vs Post)

Variable	t-value	p-value	Significance
Anterior Reach	4.21	0.0002	Significant
Posteromedial Reach	4.78	0.0001	Significant
Posterolateral Reach	4.35	0.0002	Significant

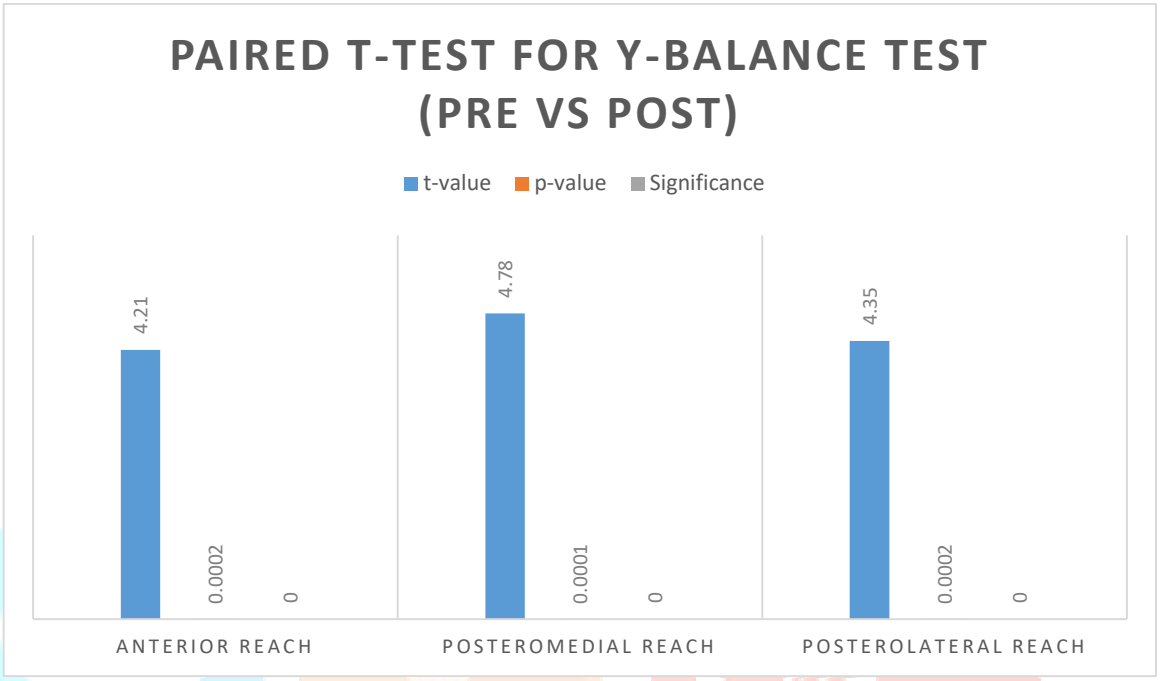


Table 4.7: Paired t-test for Gluteal Activation

Variable	t-value	p-value	Significance
Gluteus Maximus	5.02	0.0001	Significant
Gluteus Medius	4.65	0.0001	Significant

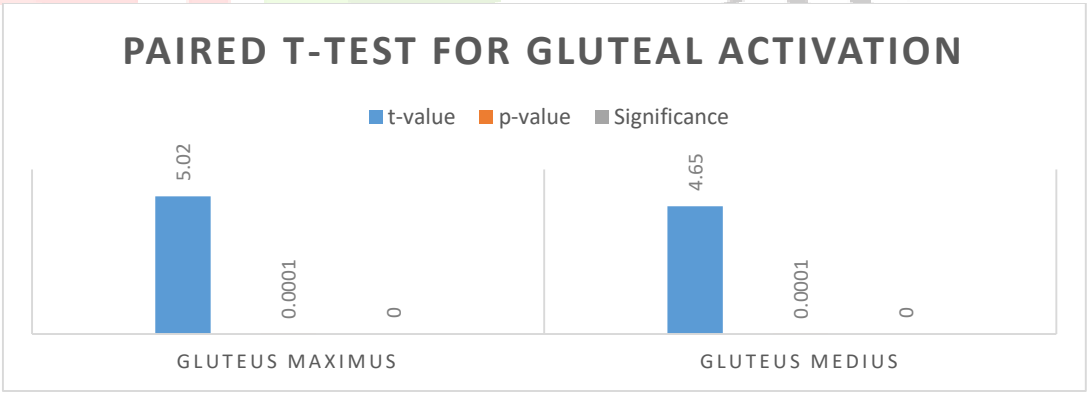
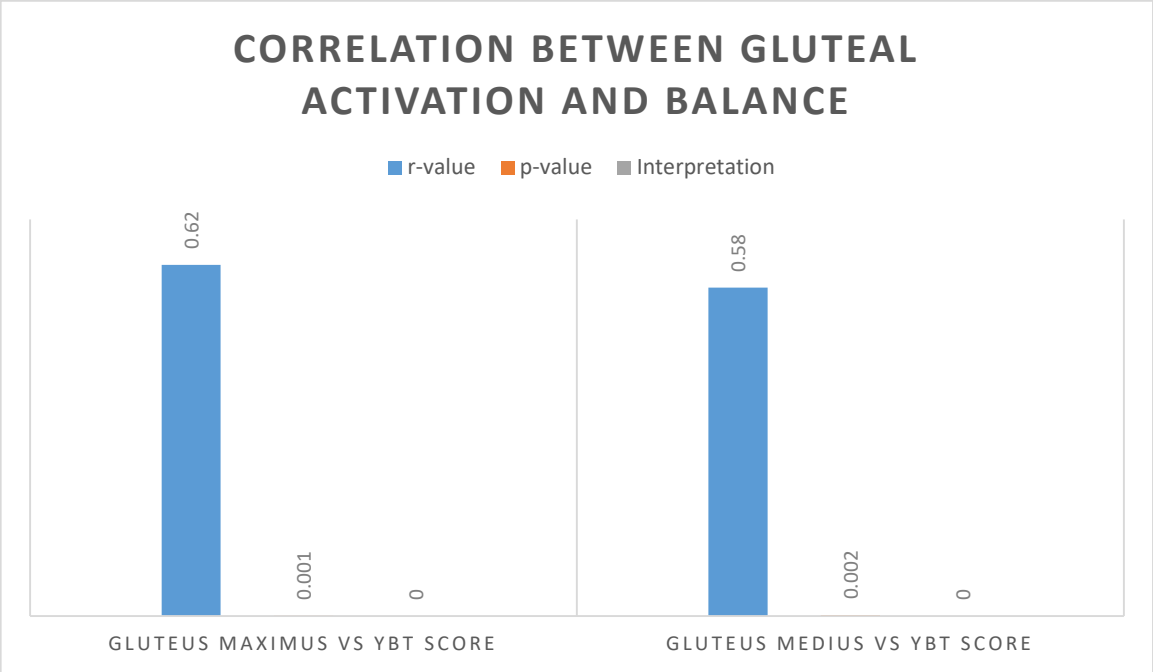


Table 4.8: Correlation Between Gluteal Activation and Balance

Variables Compared	r-value	p-value	Interpretation
Gluteus Maximus vs YBT Score	0.62	0.001	Moderate Positive
Gluteus Medius vs YBT Score	0.58	0.002	Moderate Positive

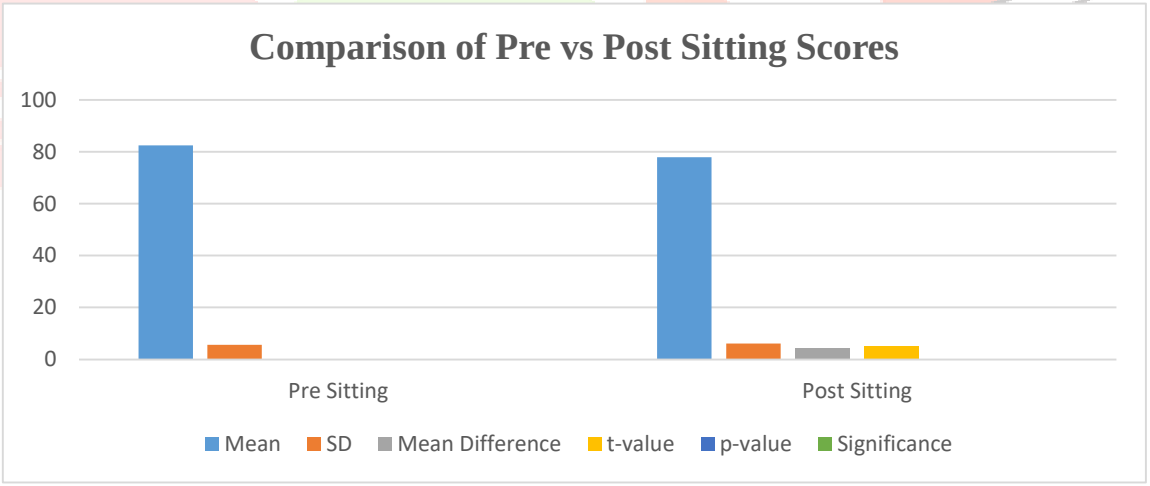


4.4 Comparison Between Groups

In this study, comparison was made between **pre-sitting and post-sitting conditions** to evaluate the effect of prolonged sitting on gluteal activation and postural stability.

Table 4.9: Comparison of Pre vs Post Sitting Scores (YBT Composite Score)

Condition	Mean	SD	Mean Difference	t-value	p-value	Significance
Pre Sitting	82.4	5.6	0	0	0	-
Post Sitting	77.9	6.1	4.5	5.12	0.0001	Significant



Interpretation:
The composite Y-Balance Test score significantly decreased after prolonged sitting ($p < 0.05$), indicating reduced overall postural stability.

Table 4.10: Comparison of Gluteal Activation (Pre vs Post)

Condition	**Mean ± SD (µV)**	**Mean Difference**	**t-value**	**p-value**	**Significance**
Pre Sitting	50.5 ± 5.8	—	—	—	—
Post Sitting	43.6 ± 5.7	6.9	5.34	0.0001	Significant

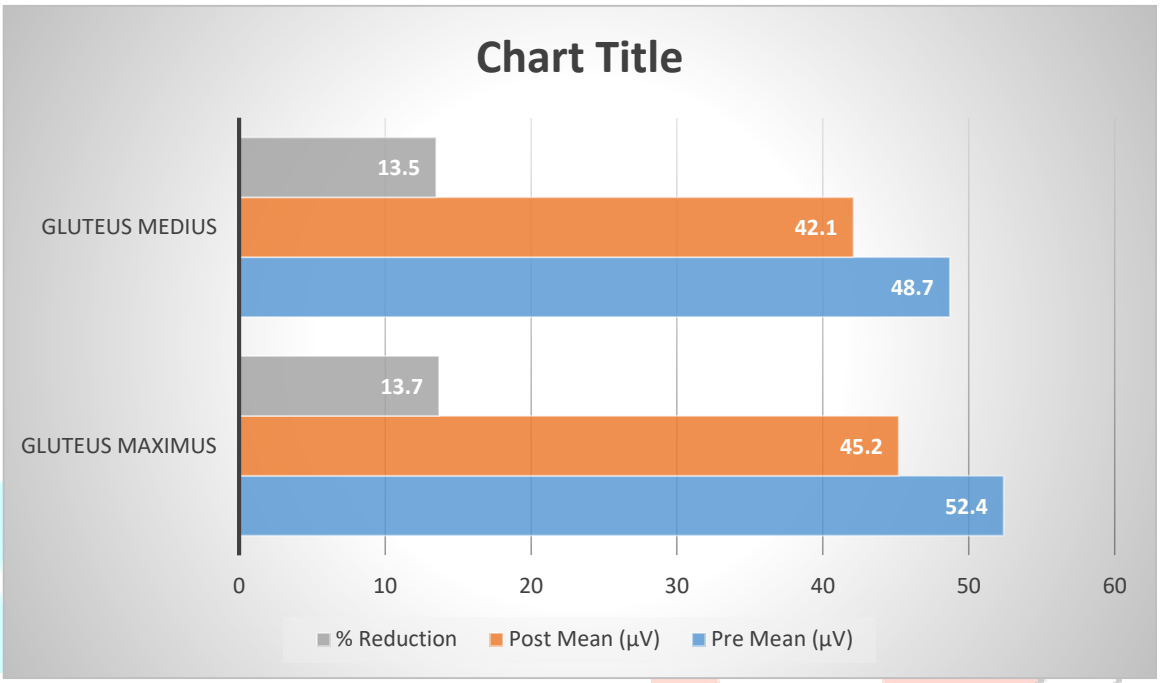
Interpretation:
There is a statistically significant reduction in gluteal muscle activation after prolonged sitting.

4.5 Effect of Sitting on Gluteal Activation

The effect of prolonged sitting on gluteal muscle activity was assessed using EMG recordings before and after the intervention.

Table 4.11: Percentage Reduction in Gluteal Activation

Muscle	Pre Mean (µV)	Post Mean (µV)	% Reduction
Gluteus Maximus	52.4	45.2	13.7
Gluteus Medius	48.7	42.1	13.5



Interpretation:
Both gluteus maximus and medius showed approximately **13–14% reduction** in activation following prolonged sitting, confirming the presence of gluteal inhibition.

Explanation (for viva):

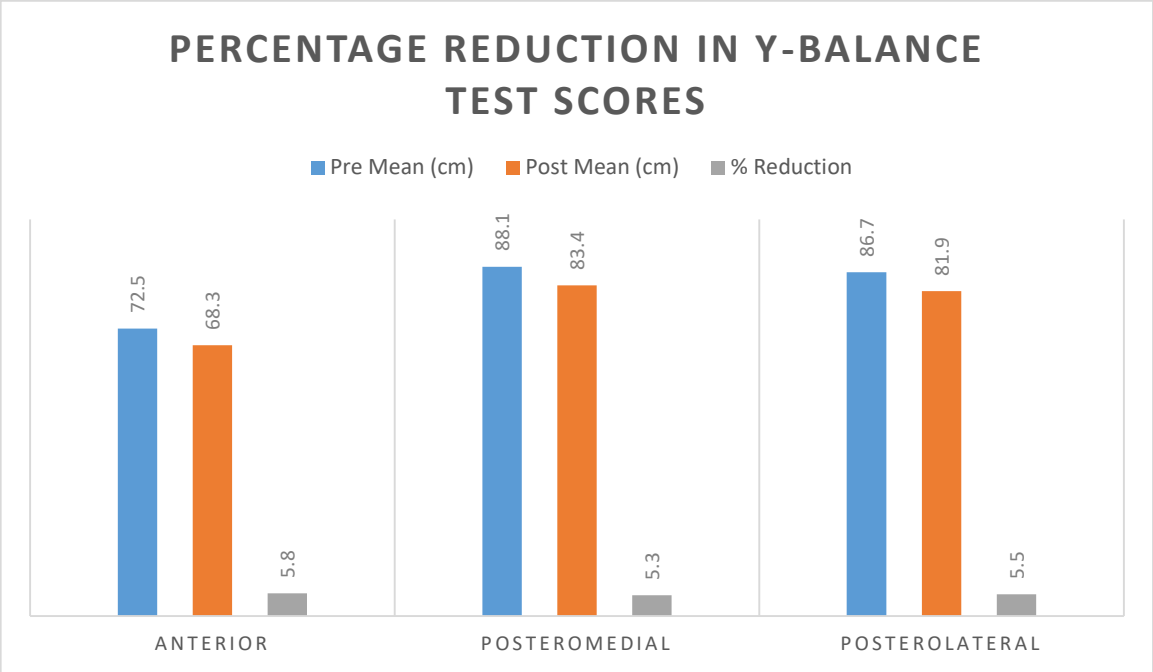
This reduction suggests that prolonged sitting leads to decreased neuromuscular efficiency, which may impair the ability of the hip to stabilize the lower limb during functional activities.

4.6 Effect on Postural Stability

Postural stability was assessed using Y-Balance Test reach distances before and after sitting.

Table 4.12: Percentage Reduction in Y-Balance Test Scores

Direction	Pre Mean (cm)	Post Mean (cm)	% Reduction
Anterior	72.5	68.3	5.8
Posteromedial	88.1	83.4	5.3
Posterolateral	86.7	81.9	5.5



Interpretation:
All directions showed a **5–6% decrease in reach distance**, indicating a decline in dynamic balance performance after prolonged sitting.

Explanation (for viva):

Reduced reach distances reflect impaired neuromuscular control and decreased ability to maintain stability during movement. This supports the idea that gluteal inhibition negatively affects postural control.

CHAPTER 5: DISCUSSION

5.1 Interpretation of Findings

The current research investigated the influence of gluteal inhibition in prolonged sitting on the stability of posture among people with chronic ankle joint instability (CAI). The findings showed that both the gluteal muscle performance and dynamic balance parameters significantly decreased after the sitting protocol.

In particular, EMG records showed that there was a definite decrease in the activation of gluteus maximus and gluteus medius following excessive sitting. Simultaneously, dynamic stability was not maintained with decreased reach distances in all directions in Y-Balance Test scores. The size and constancy of these changes are indicative that even such a brief stint of sustained sitting impact neuromuscular activity adversely.

These results verify the notion that proximal muscle dysfunction is a contributor to distal instability. In patients with CAI who are already at a disadvantage due to a weak ankle control, lower levels of gluteal perhaps decreases abilities of the body in maintaining a balance with the functional tasks.

5.2 Comparison with Past Research.

The results of this paper support previous studies which have highlighted imbalance status and neuromuscular incompetence effects in persons with chronic ankle instability. Past reports have demonstrated that CAI is expected to decrease the performance in dynamic balance assessment including Star Excursion Balance Test (SEBT) and Y-Balance Test (YBT).

Moreover, previous studies have also established delayed muscle activation and proprioceptive impairments as an important contributor to instability. The current study builds on these findings, by showing that gluteal muscle inhibition especially through protracted sitting, can be a further contributive factor.

Articles dedicated to the strength of hips have also indicated that lesser gluteal tensions are associated with poor lower limb positioning and injury prone conditions. The findings at the moment are in line with this evidence point, indicating that hip is vital towards keeping the posture balanced.

Nonetheless, the present study is significant unlike most of the past researches that have only targeted impairments of the ankle; the study emphasizes on utilizing both proximal and distal parts of the kinetic chain which gives a better insight into CAI.

5.3 Biomechanical Explanation

To gain a biomechanical explanation of the observed decrease in postural stability, the idea of the kinetic chain can be applied. Lower extremity is a complex system where the knee, hip, and ankle are interdependent to help in maintaining balance and force-distribution.

During one-legged position, the gluteal muscles especially the gluteus medius are instrumental in stabilizing the pelvis. Inhibition of these muscles gives way to pelvic stability resulting in:

- Femoral internal rotation.
- Knee valgus positioning
- Altered foot mechanics
- Stress on the ankle joint.

Such changes can also lower the balance capabilities in people with CAI. The ankle joint already compromised by the instability may not be able to offset the absence of proximal control and then lead to a compromise of the postural stability.

Also, the decrease in the activation of the gluteal muscles can also decrease the usefulness of the hip strategy, which is a necessary element to preserve the balance in bigger perturbations. This shifts to the ankle approach which might not be adequate in CAI patients.

5.4 Neuromuscular Implications

This research has some valuable neuromuscular implications. Sustained sitting seems to slow down the excitability and responsiveness of the gluteal muscles and result in slow-or- inadequate activation in the context of functional tasks.

Such a weakening of muscle activity may interfere with normal muscle motor patterns, leading to:

- Poor coordination among body muscles.
- Slowness in responding to balance problems.
- A higher dependence on compensatory measures.

In CAI, the already compromised proprioceptive ankle input can be further diminished by the decrease in gluteal activation, which can further affect neuromuscular control. This may result in inefficient movement patterns and the risk of recurrent injuries is higher.

The findings indicate that neural motor impairments in CAI may not be specific to the ankle area but affect the whole lower extremity, including proximal muscles.

5.5 Clinical Relevance Physiotherapy.

The results of this research have significant implication in the practice of physiotherapy. Conventional CAI rehabilitation is primarily based on the ankle strengthening and training proprioception and balance. Although these methods are necessary they might not be adequate when proximal dysfunction is not covered.

These findings indicate that:

- The gluteal muscle functionality should be evaluated during CAI assessment.
- Rehabilitation plans (programs) must include hip strengthening and activation exercises.
- Strategies to minimize prolonged sitting and encouragement of regular movements should be highlighted.

The physiotherapists are to have a comprehensive approach, focusing on both the proximal and distal parts of the kinetic chain. This can enhance treatment results and decrease the chance of a relapse.

5.6 Importance of Hip Strength in Ankle Stability.

The strength of hips, especially the gluteal muscles is very important in lower limb stability. Active and healthy gluteal muscles aid in maintaining pelvic position, femoral posture and the entire mechanics of movement.

Better hip strength is able to:

- Enhance dynamic balance
- Lessen abnormal joint loading.
- Improve neuromuscular coordination
- Promote ankle stability in functional activities.

Gaining proximal control, gluteal muscles can off-load ankle deficits in individuals who have CAI. This may result in improved balance performance and decreased risk of additional injury.

The current research supports the necessity of hip fortification as an essential part of the rehabilitation programs of CAI. It also refers to the necessity to consider lifestyle aspects, including sitting, that can cause muscle inhibition.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Summary of Findings

The aim of the current research was to explore the effect of gluteal inhibition with prolonged sitting among chronic ankle instability (CAI) patients on postural stability. The experimental design was a within subject experimental study to compare pre and post sitting dynamic balance and gluteal muscle activity measurements.

Findings of the study are mainly summarized as follows:

There was a marked decrease in the gluteal muscle activity (gluteus maximus and gluteus medius) following prolonged sitting.

- The decrease in postural stability was also significant as reflected by smaller reach distances in the Y-Balance Test in each direction.
- The findings showed that there is moderate positive correlation between gluteal activation and performance of balance and that decreased muscle activation is a causative factor contributing to the disrupted stability.
- Prolonged sitting was found to be a possible contributory factor towards neuromuscular dysfunction, especially among people who already have ankle instability.
- On the whole, the conclusions indicate the significance of taking into consideration both the proximal and distal factors when measuring the postural stability.

6.2 Conclusion

According to the research findings, one can conclude that protracted sitting causes considerable gluteal muscular depression that consequently adversely influences the postural stability of the patients with the chronic ankle instability.

According to the research, the concept that the lower limb is an integrated kinetic chain is supported. Stability at the ankle joint can be compromised due to dysfunction at the hip level especially a decrease in the activation of the gluteal muscles. This becomes more noticeable in people who have CAI as they already have deficits in proprioception and neuromuscular control.

Thus, the postural instability of CAI cannot be explained only by the ankle impairment. Rather, it is the product of a set of factors, such as the work of the proximal muscles, lifestyle factors, like excessive sitting.

The results of the proposed research underpin the alternative hypothesis and illustrate the necessity of a more integrated approach to the comprehension and treatment of chronic ankle instability.

6.3 Clinical Implications

These findings of the present study have also some significant implications on clinical practice, specifically on physiotherapy and rehabilitation.

- Assessment of patients with CAI needs not be confined to the ankle joint alone but should extend to include an assessment of hip and gluteal muscle functioning.
- Gluteal strengthening and activation exercises should be included in the rehabilitation program of enhancing overall lower limb stability.
- Clinicians: should become aware of the effects of prolonged sitting and recommend that the patients curb sedentary activities.
- Functions training to combine balance, strength, neuromuscular control must be highlighted.
- Early detection of gluteal inhibition could probably aid in avert ankle injuries recurrence.
- Clinicians can increase treatment efficacy and better functional functioning in CAI individuals by taking a more global view of autism.

6.4 Recommendations for Practice

According to the results of the present work, the following recommendations can be proposed on both clinical and practical implementation:

Actions: Include hip-centered activities in the standard rehabilitation programs, including glute bridges, clamshells, and lateral band walk.

- Implement balance training, which is dynamic and involves such devices as the Y-Balance Test as an evaluation tool and intervention.
- Promoters should urge the person to avoid sitting and to take frequent body breaks in order to use the muscles.
- Use neuromuscular training programs which address coordination and movement control.
- Educate patients on the need to sit well, do stable exercises.

Such training methods can contribute to enhancing postural control and minimizing the possibility of repeated ankle instability.

6.5 Future Research Recommendations.

Although the current study has some important information, some specific points need to be explored more:

- Pursue research that has a better sample size in order to enhance the extent of generalization of findings.

- Investigate the chronic impacts of sitting on muscle activity, and balance.
- Hypothesis: Usefulness of combined hip and ankle rehabilitation in CAI.
- Motion analysis systems and wearable sensors can be used to provide more detailed assessment with more advanced tools.
- Look at how various lengths of sitting and postures can affect the glutal activation.
- Compare the same relationships in other populations, e.g., older adults or athletes.

Future studies in these directions can help to better understand the association between sedentary behavior and muscle activation and postural stability.

CHAPTER 7: STUDY Limitation.

Any research study comes with some limitations that can affect the interpretation and generalization of the research findings. There are also certain limitations in the current study as discussed below:

Small Sample Size

The research involved an expression of a relatively small number of participants whose number can reduce the saturation of the findings. In a within subject design, the sample size was adequate to find significant differences but a bigger sample would have given stronger and better results.

The small sample size can also cause a risk of sampling bias with a lack of generalizability to a wider population. It is advisable to conduct a study with bigger and more varied samples in the future to increase the validity of the results.

Limited Time Sitting in the spot.

Prolonged sitting was kept to a limited time in this study (e.g., 12 hours). Though this was adequate to result in short-term changes in gluteal activation and postural stability, it might not be a full picture of the actual in real life sedentary behaviour, where people tend to sit longer hours.

The short-term approach of the intervention method does not allow evaluating the long-term adaptations or the cumulative effects of long-term sitting. To gain a more comprehensive insight into the chronic effects, existence longer periods and repetitive exposure should be included in future research.

Limited Generalizability

The sample of the study was mainly composed of young adults in a range of ages and activity level. Consequently, the results cannot be directly extrapolated to other groups of the population, including older adults, children, and persons with variable degrees of physical activity.

Also, the participants were chosen according to some inclusion criteria, the aspect of chronic ankle instability, which further restricts the extrapolation of the findings to the general population.

Future researchers need to have a wider sample regarding age, gender, and background occupation to increase the external validity.

Equipment Limitations

Though the assay was assessed by some of the most reliable tools, some limitations were associated with the availability of equipment and accuracy.

For example:

- Surface EMG owes its usefulness to factors like electrode placement and skin impedance.
- Not used: Advanced motion analysis system (that would have provided more detailed biomechanical information).

- Force plate analysis unless regularly available can also restrict the accuracy of postural stability measurements.

These constraints can have an impact on the accuracy of data obtained. Incorporation of more sophisticated and standardized equipment would have been beneficial to subsequent research to enhance the accuracy of measurements.

Ending Some Overall Limitation Statement (Important)

Regardless of these shortcomings, the study offers substantial levels of information on the association between prolonged sitting, gluteal inhibition and postural stability in people with chronic ankle instability. The results can be used to base subsequent studies in the field.

CHAPTER 8: FUTURE SCOPE

The current study offers valuable suggestions on the interaction of long sitting, gluteal inhibition and postural stability in patients with persistent ankle instability. Nevertheless, one can identify several domains, in which the existing findings can be extended and reinforced by additional research. Future of this research as discussed below:

Long-Term Longitudinal Studies

The present analysis was mainly aimed at the acute implication of long sitting on gluteal engagement and posture stability. Research in the future ought to take the longitudinal design to determine the long-term effects of sedentary behavior on neuromuscular functioning.

Long term research could assist in inferring:

- The long-term consequences of sitting during weeks or months.
- Gluteal inhibition over time is chronic or not.
- The development of postural instability in CAI patients.

These studies would give more insight as to the role of lifestyle habits in musculoskeletal dysfunction and risk of injury.

Advanced Biomechanical Analysis

To get more specific and detailed data, the use of the sophisticated methods of biomechanical assessment may be introduced in future studies.

These may include:

- 3D motion analysis systems: Movements can be analyzed in detail using motion tracking cameras.
- Force plate systems to measure center of pressure and sway patterns accurately.
- Hit-resolution EMG to analyze muscle activation.

With the help of advanced tools, researchers could gain a better insight into the interaction of various joints and muscles as part of the kinetic chain. It would also enable more depiction of patterns of movements and compensatory processes.

Combination with Rehabilitation Protocols.

The other potential area of study that should be done in future is incorporation of the findings into a formalized rehabilitation program. Although this research opens up to the importance of gluteal inhibition, the effectiveness of targeted interventions needs to be explored in future research.

Studies may be conducted on:

- Comparison of traditional ankle rehabilitation and combined hip and ankle programs.
- Status: The study aims to assess the effectiveness of gluteal activation exercises in enhancing balance.
- Evidence-based rehabilitation procedures to cover the kinetic chain.

The direct clinical use and applications of such studies would enhance the treatment outcomes of individuals with CAI.

Wearable Sensors.

Wearable technology is a potential avenue of future research. Wearable sensors have the potential to give real-time information about movement, posture, and muscle activity within a clinical and real-life environment.

Potential applications include:

- Observing sitting time and position in the daytime.
- Evaluation of muscle activity in everyday activities.
- Monitoring balance and movement pattern out of the laboratory.

Wearables will be able to promote ecological validity of research by gathering natural environments. They also provide the possibility to conduct monitoring constantly and offer individual rehabilitation programs.

Overall Future Perspective

A more comprehensive and technology based approach in gaining insight into postural stability and musculoskeletal functioning should feature in future research. The integration of long-term study designs, sophisticated assessment instruments, and rehabilitation approaches can allow gaining a better insight into the contribution of gluteal muscles in ankle stability.

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